

# *USDA Caribbean Climate Hub: Addressing Climate Change, Agriculture, and Forestry in Puerto Rico*

*William A. Gould, Isabel K. Parés. Stephen J. Fain, Kathleen McGinley, Nora Alvarez*



## **CARIBBEAN CLIMATE HUB**

for Tropical Forestry and Agriculture

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Tropical Forestry, Río Piedras, Puerto Rico



**USFS International Institute of Tropical Forestry**

# *OUTLINE*

- Climate Hub mission, vision and leading institutions
- Starting point: Current state of agriculture, forestry and climate
- Assessments: knowing vulnerabilities and knowing stakeholders
- Strategies: Build on science, deliver to stakeholders
- Tools and products
- Next steps



**USFS International Institute of Tropical Forestry**

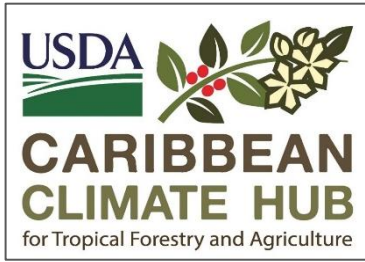


***Mission:*** To deliver science-based knowledge, practical information and program support to farmers, ranchers, forest landowners, and resource managers to support decision-making related to climate change.



***Vision:*** To ensure food, water, and other vital resources continue to be available by sustaining and strengthening the services provided by Caribbean working lands and rural communities in the face of climate change.

**USFS International Institute of Tropical Forestry**



Forest Service

*Lead Institution:*  
*International Institute of Tropical Forestry*

**University of Puerto Rico Río Piedras Campus**

56 employees working with adjunct  
personnel, volunteers, contractors,  
students, and visitors.

10 permanent scientists, 7 duty stations

Research and Development

State and Private Forestry

International Cooperation

Administration

Established 1939







# Natural Resource Conservation Service *Partner Institution:* *NRCS Caribbean Area*

Edwin Almodovar, Caribbean Area Director

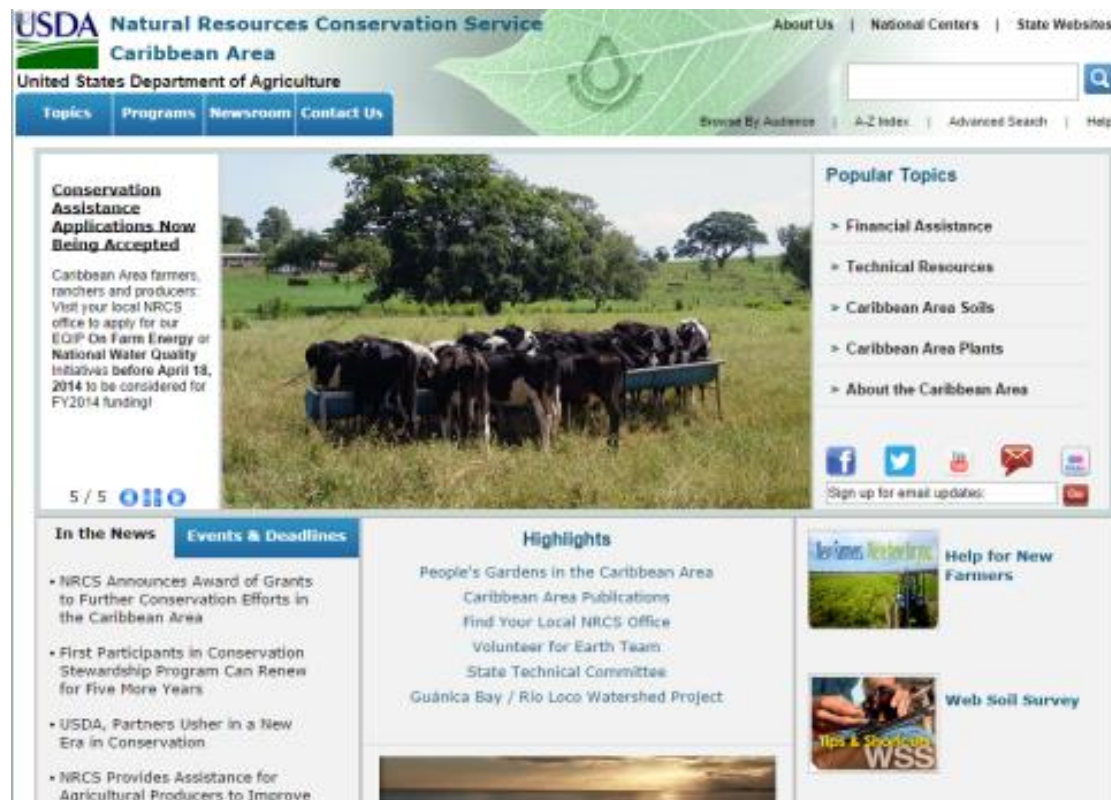
San Juan, Puerto Rico

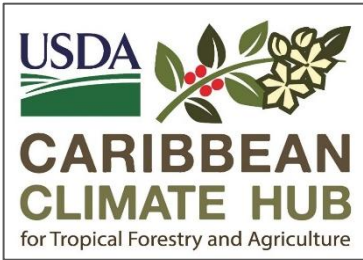
62 employees

9 field offices

14 programs

Work to sustain and improve the quality of our soil, water, air and wildlife habitat. NRCS develops conservation plans that work for the land and for farmers and ranchers.





Agricultural Research Service

*Partner Institution:*

*Tropical Agriculture Research Station*

Ricardo Goenaga, Station Director

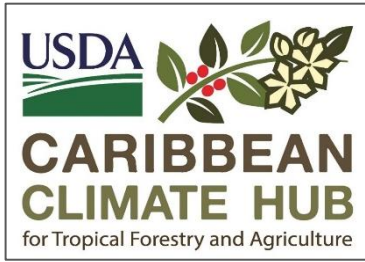
**University of Puerto Rico Mayagüez Campus**

**22 employees**

Scientists work internationally  
with a focus on Tropical  
Crops and Germplasm  
Research.







## Background

# *Climate Related Research at the International Institute of Tropical Forestry*

- 1943 – Tree plots established in the Luquillo Experimental Forest
- 1980 – Long Term Ecological Research – Tropical dry and wet forest
- 1995 – Large Scale Biosphere-Atmosphere Experiment in Amazonia
- 2000 – Measurements along elevational / climatic gradients
- 2003 – Hurricane simulation: Canopy Trimming Experiment
- 2009 – Luquillo Critical Zone Observatory: Tropical landscape evolution
- 2012 – Caribbean Landscape Conservation Cooperative
- 2014 – Caribbean Climate Hub
- 2015 – Next Generation Ecological Experiments -Tropics
- 2016 – TRACE: Tropical Forest Warming Experiment



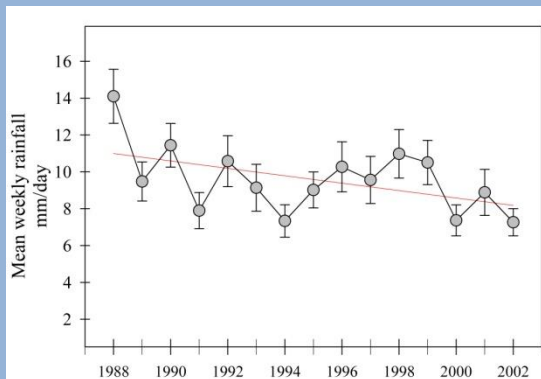
## Background

# Collaborative research activities

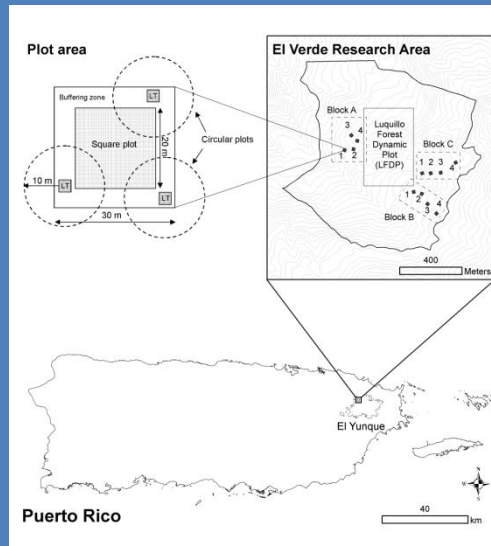
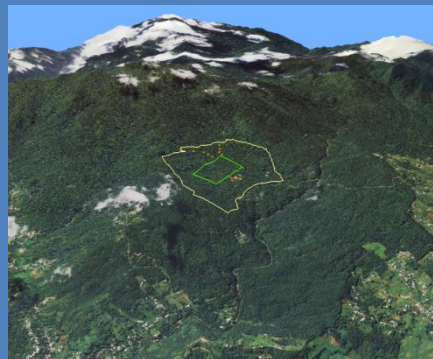
*Long term monitoring, experimental studies, modeling, mapping*

### National/International networks

LTER	FIA
ULTRA	LBA
NEON	GAP
LCZO	LCC
WEBB	EFR



Heartsill Scalley, T., F.N. Scatena, C. Estrada, W.H. McDowell, and A.E. Lugo. 2007. Disturbance and long-term patterns of rainfall and throughfall nutrient fluxes in a subtropical forest in Puerto Rico. *Journal of Hydrology* 333:472-485.



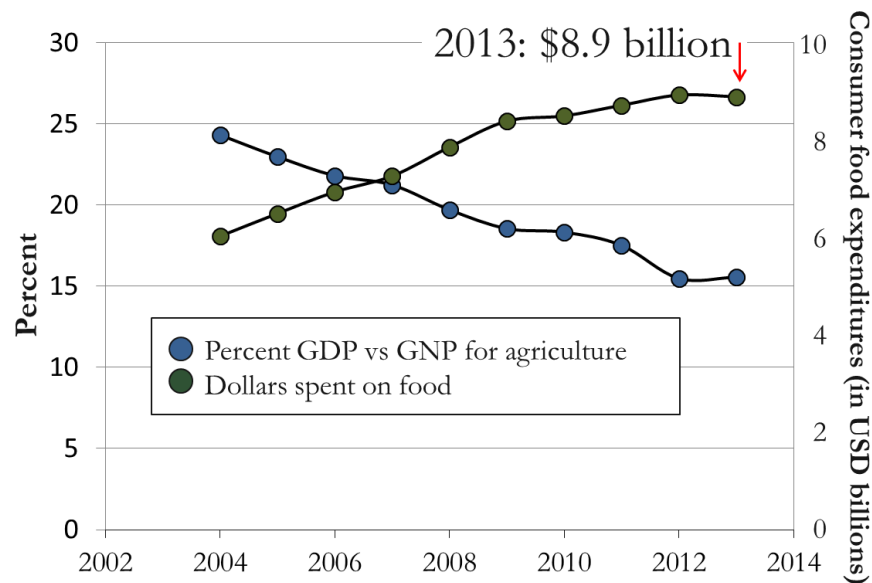
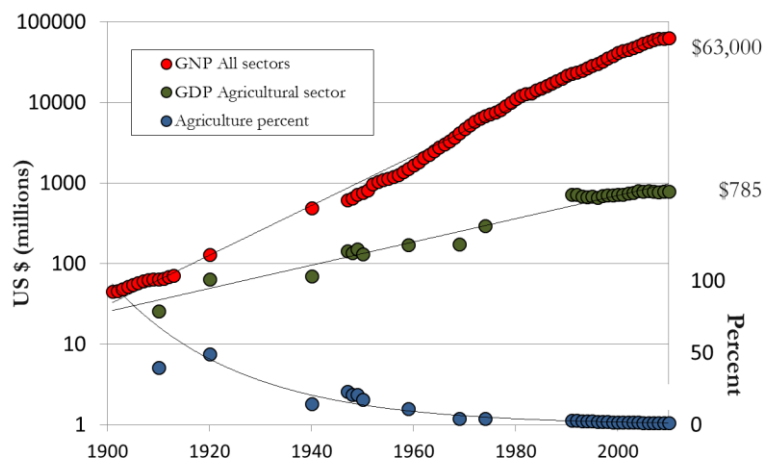
Luquillo Experimental Forest El Verde research area, (LTER) long term forest dynamics plot, Canopy trimming experiment

Partnerships occurring at all levels: among scientists, institutions, agencies



## State of Agriculture in Puerto Rico

Relative contribution of the agricultural sector in Puerto Rico to the economy declined from 50% (1900s) to < 1% (2013).



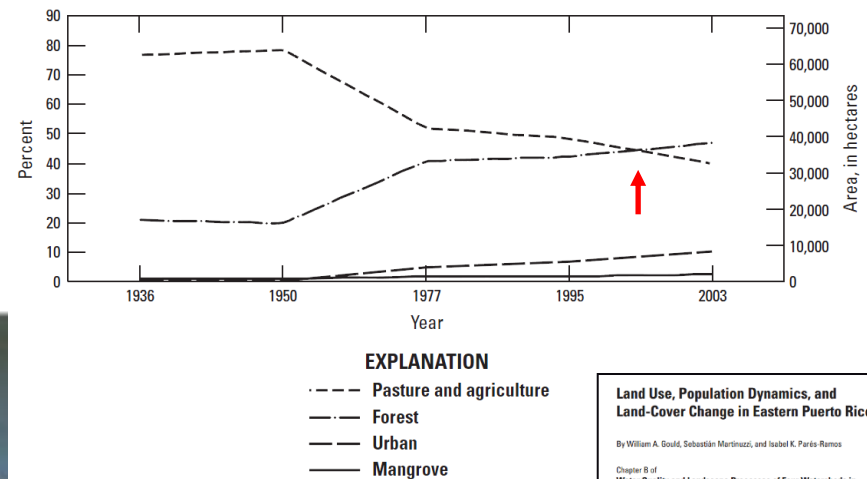
\$9 billion spent on food annually but only 15% locally grown.

# *State of Forestry in Puerto Rico*

Mid 1900s: Deforestation for lumber and agricultural clearing peaks (from the National Archives).



2000: Secondary forest cover exceeds non forest cover.

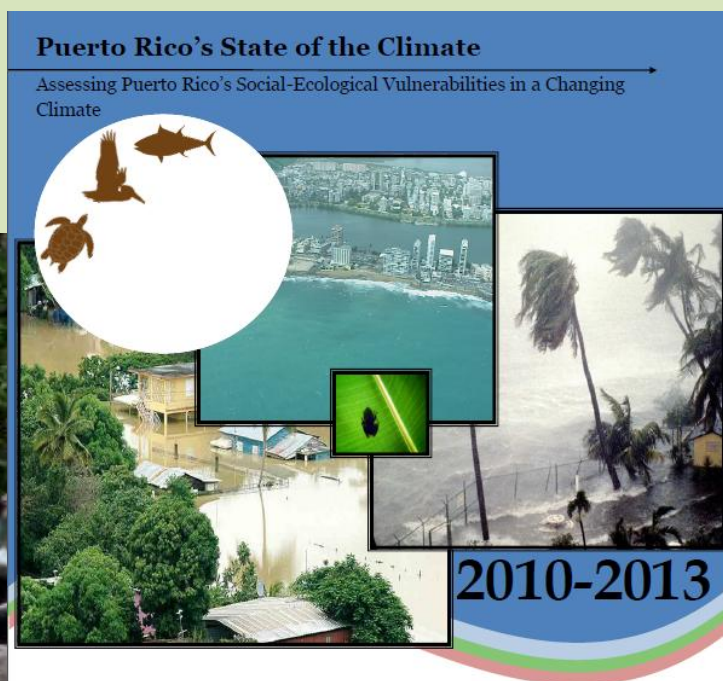




# State of the Climate in Puerto Rico

## Conservation and Society

## Vulnerabilities by Resource



### EXECUTIVE SUMMARY—ENGLISH VERSION



### SHOREBIRDS & SEABIRDS

- 1. Increased precipitation** may modify nesting habitat conditions, availability and abundance of food resources, cause nest abandonment, or even death of young and adults.
- 2. Increased severity of storms** may destruct habitat and result in unsuitable nesting areas in subsequent years, and impaired food acquisition.
- 3. Increased irradiation and mean temperatures** may alter adult nest attendance and prey fish behavior; indirectly contributing to nest failure.
- 4. Ocean acidification** (declining pH) could interfere with critical processes such as reef building, carbon sequestration via phytoplankton sedimentation, and consumer-resource interactions.
- 5. Sea Level Rise** Indirect effects of the expected sea level rise on seabirds and shorebirds include starvation during migration stopovers for re-fueling, displacement into less optimal habitat, potential increase in predation in less optimal habitat, and nest abandonment and mortality of eggs and chicks.



# Projected Rainfall Patterns for Puerto Rico 1960 -2100



A. Henareh, W. Gould, E. Harmsen, A. Terando, M. Quiñones, J. Collazo.

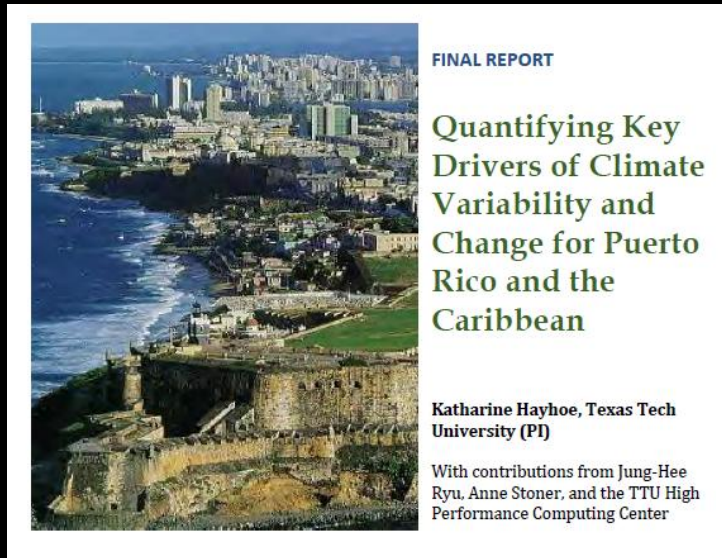
2016. *Journal of the American Meteorological Society*

Climate Change Implications for Tropical Islands: Interpolating and Interpreting Statistically  
Downscaled Global Circulation Model Projections for Management and Planning

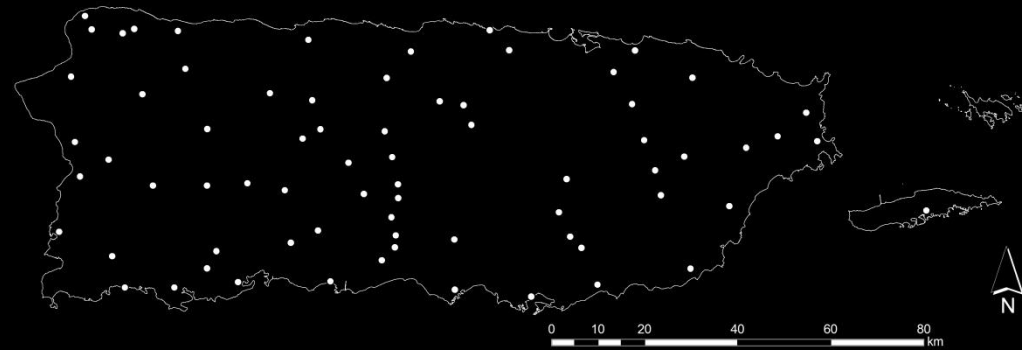




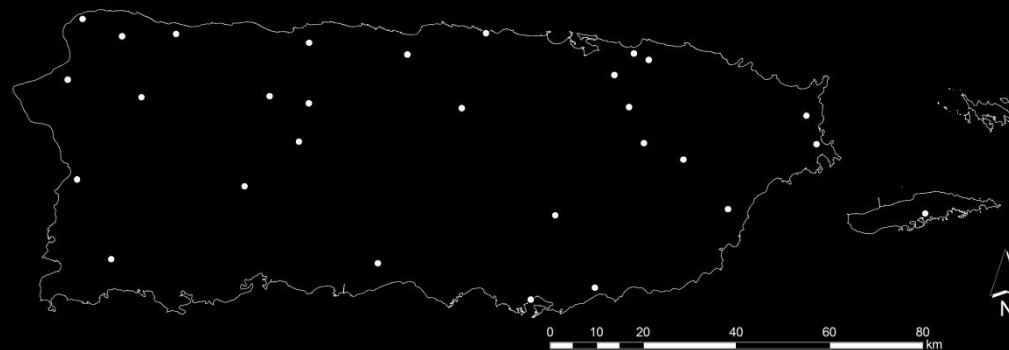
# Statistically downscaled climate data



- Hayhoe (2013) downscaled CMIP3 models to station locations
- Asynchronous Regional Regression Model (ARRM) (Stoner et al. 2012)

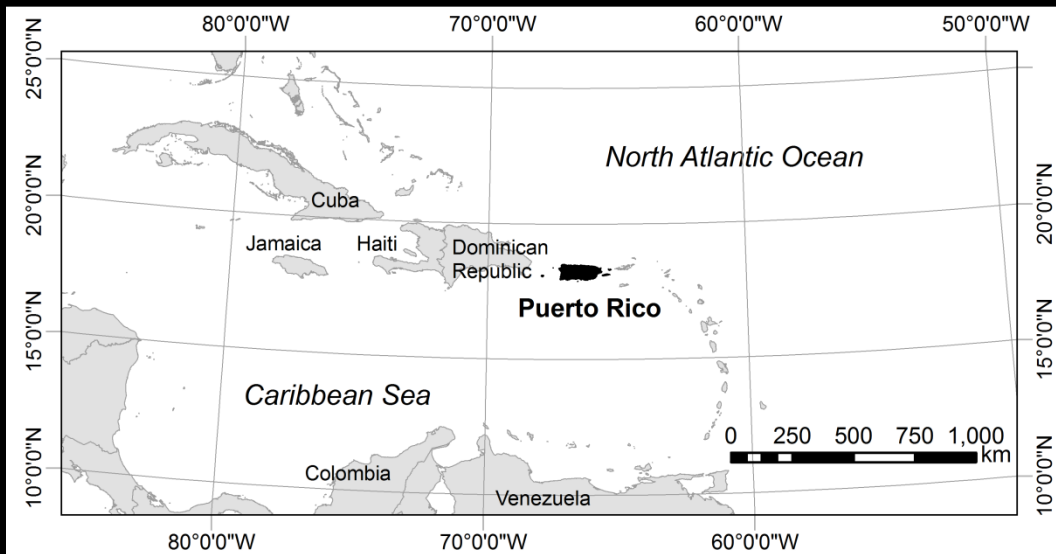


Precipitation: 71 stations



Temperature (Minimum and Maximum): 29 stations

# Model Selection and Averaging



## Variables:

- Precipitation
- Maximum temperature
- Minimum temperature

## Time intervals:

- 1960-1990
- 1991-2010
- 2011-2040
- 2041-2070
- 2071-2099

Spatial pattern of rainfall

Drought indices

Cooling degree days

Shifting life zone patterns

## Models

### Bimodal:

- CGCM3(T47)
- HADCM3
- MIROC\_MED
- MRI\_CGCM2

### Single w/MSD

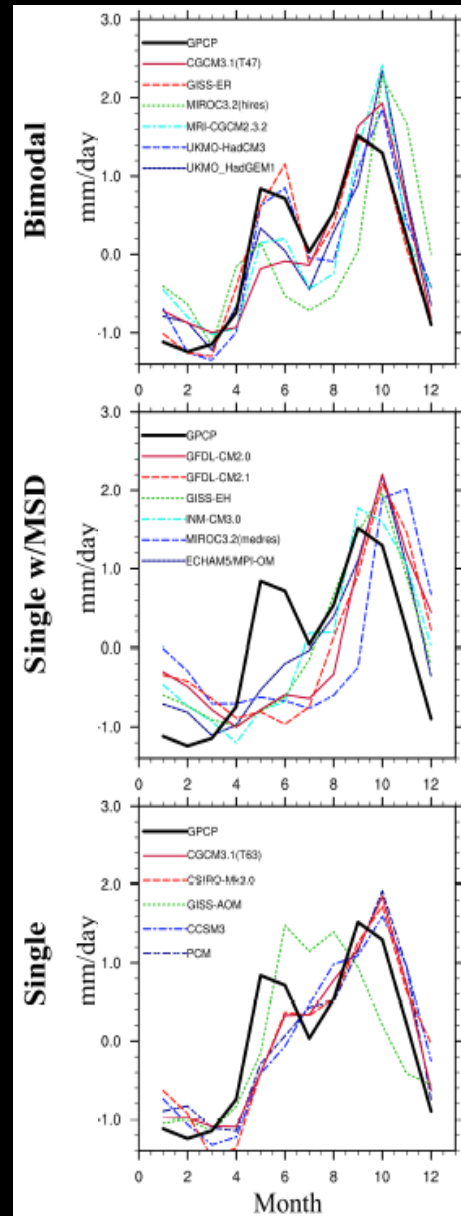
- ECHAM5
- GFDL\_2.1

### Single

- CCSM
- CGCM3(T63)
- CSIRO
- PCM

### Not evaluated

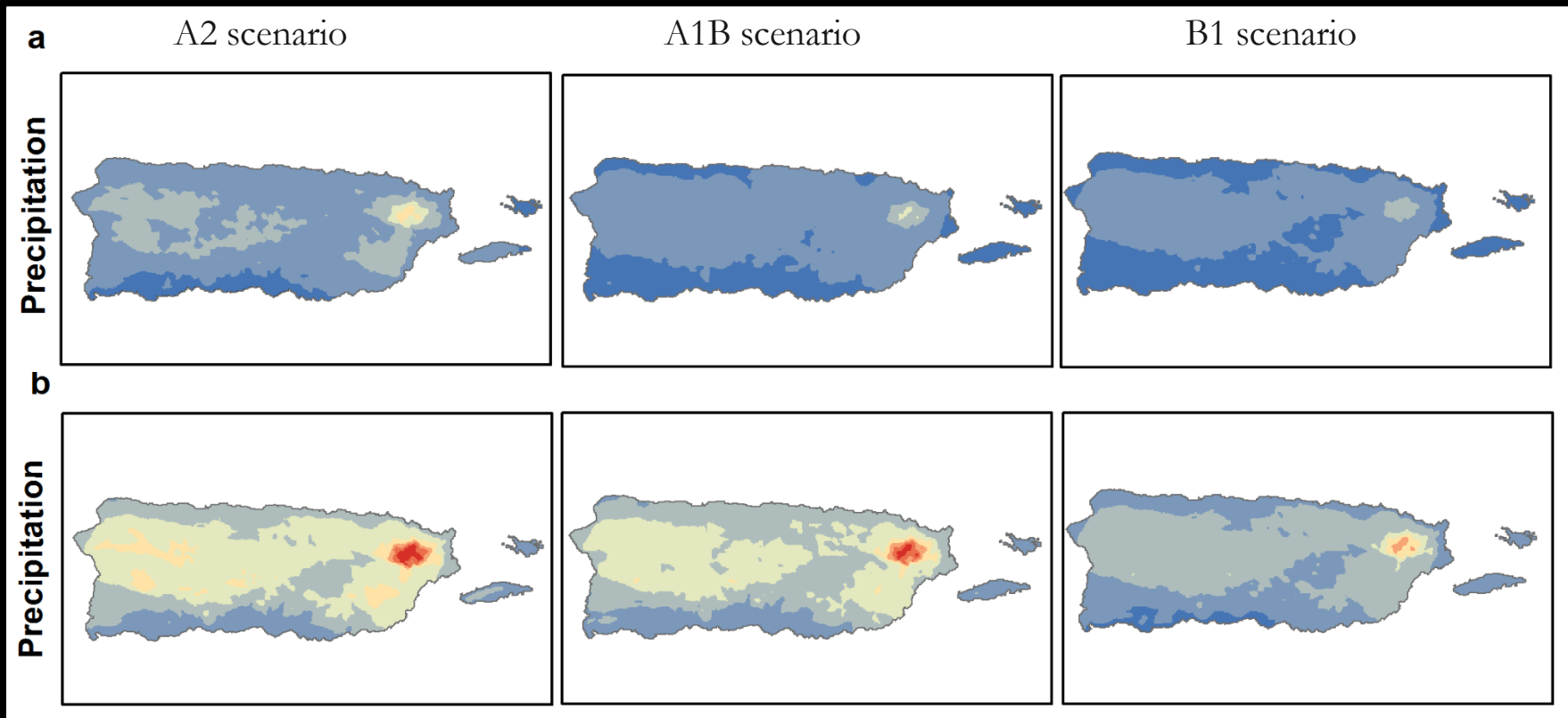
- CNRM
- ECHO



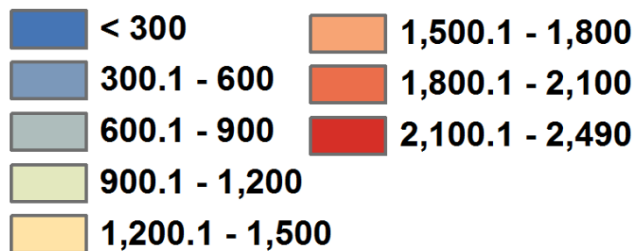
(Hayhoe, 2013)



# Changes in precipitation over next century



## Precipitation decline (mm)



Upper. All model

Ensemble:

A2: 29.80

A1B: 20.69

B1: 18.24

Lower. Bimodal

Ensemble:

A2: 53.81

A1B: 49.49

B1: 36.39

# Climate Scenarios: Mean annual temperatures

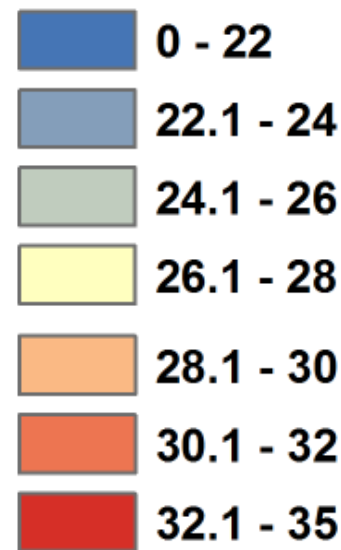
Emission scenarios: high to low

A2

A1B

B2

Legend



Mean annual temperature (°C)

All scenarios show significant increase in mean annual temperatures.

Henareh et al. in preparation.  
Downscaling: Hayhoe et al 2013.

Time

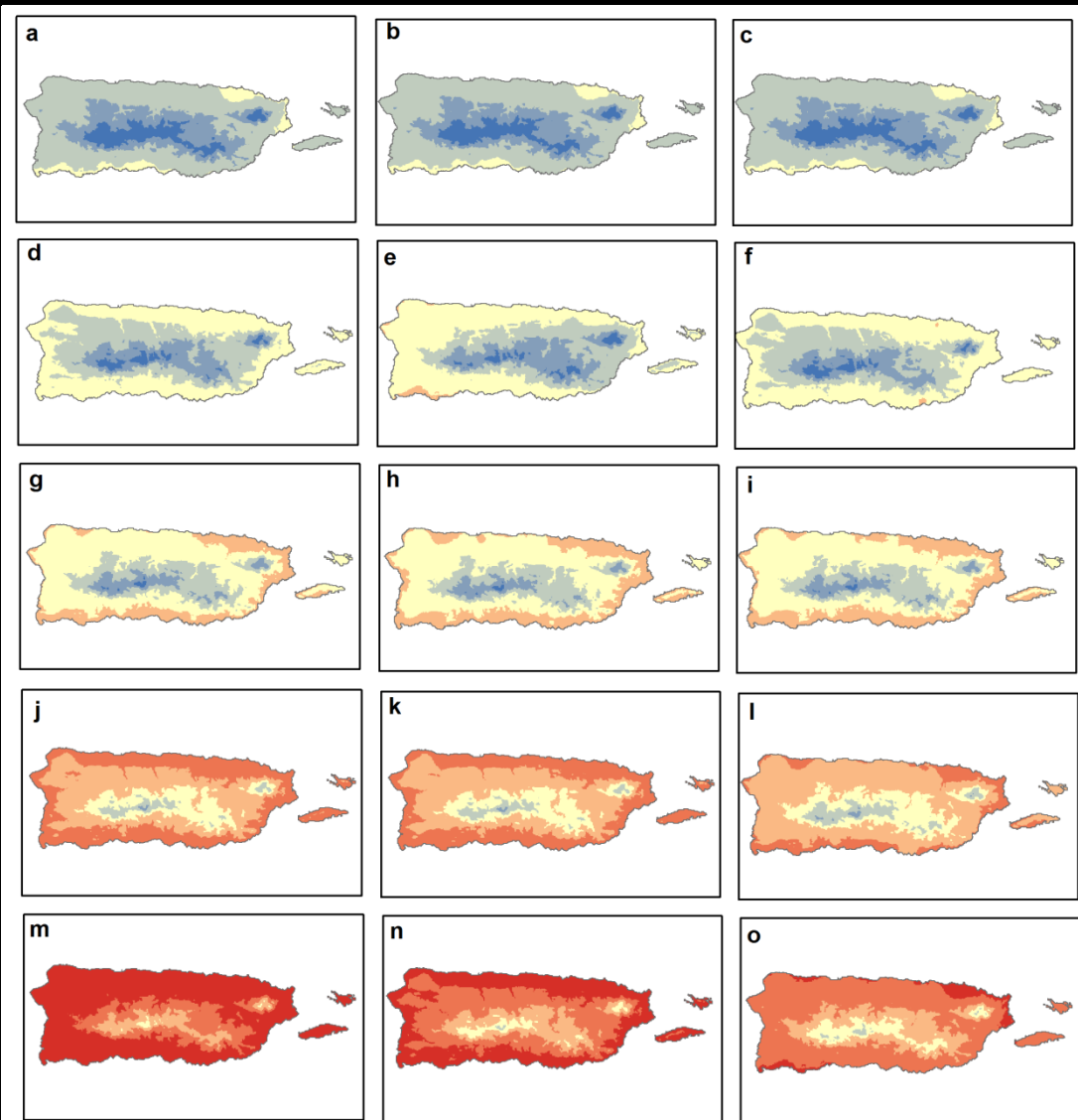
1960-1990

1990-2010

2010-2040

2040-2070

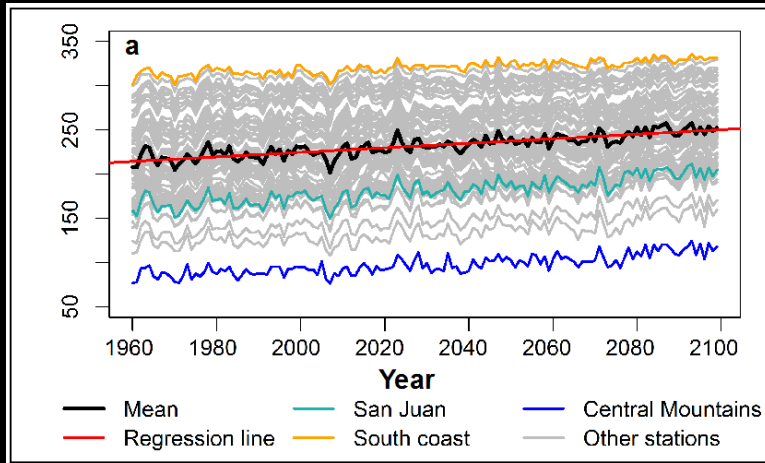
2070-2100



# Additional climate change effects

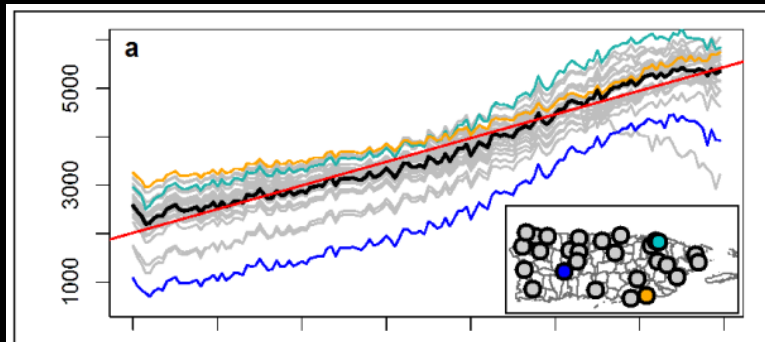
## Total dry days

Precipitation less than 1 mm.

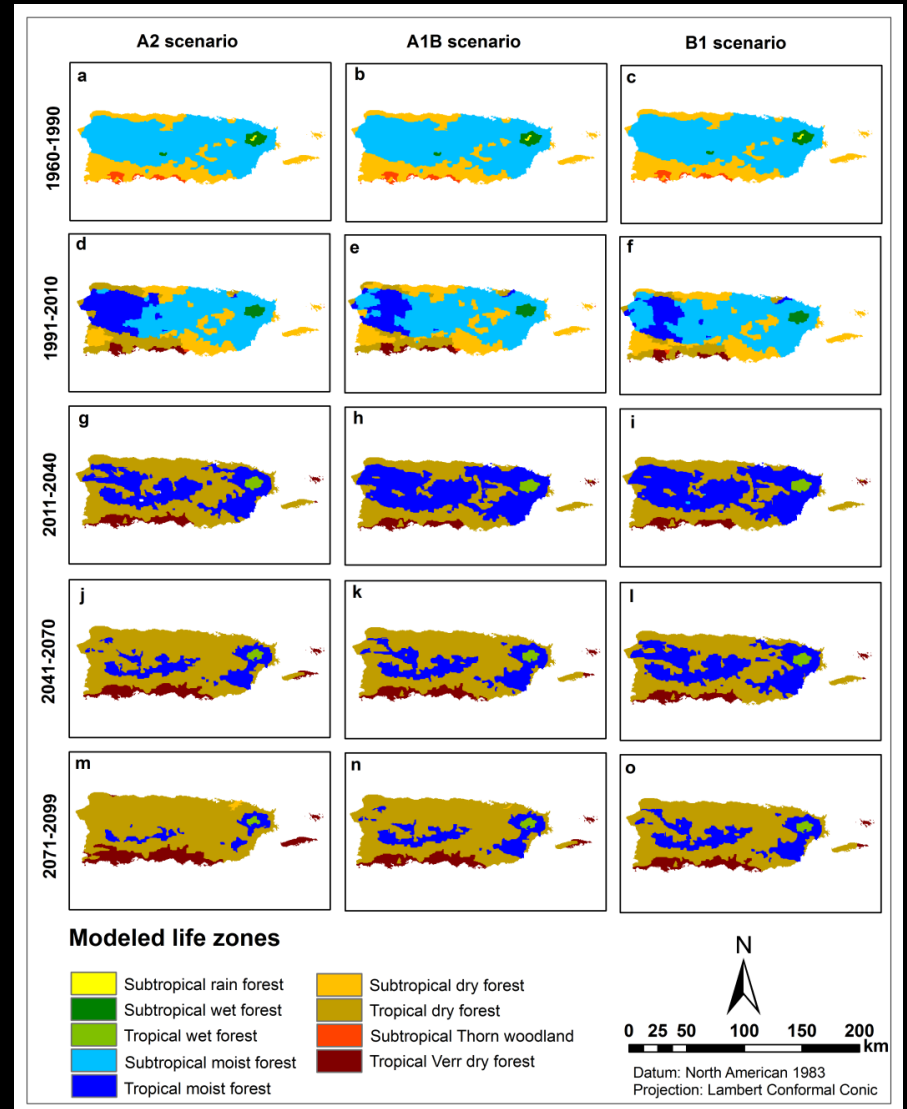


## Cooling degree days

Number of days where mean daily temperatures is greater than 18 degrees C



## Projected life zone shifts







## Assessments

# *Document vulnerabilities and adaptation practices by sector*

### Caribbean Regional Climate Sub Hub Assessment of Climate Change Vulnerability and Adaptation and Mitigation Strategies



Local produce at the farmers' market in San Juan, Puerto Rico (Photo credit: Victor Cuadrado)

**Authors:** William A. Gould, U.S. Forest Service (USFS) International Institute of Tropical Forestry (IITF) Research Ecologist, Caribbean Sub Hub Director; Stephen J. Fain, Caribbean Sub Hub Strategic Analyst, Yale University graduate student; Isabel K. Pares, Caribbean Sub Hub Coordinator; Kathleen McGinley, USFS IITF Social Scientist; Ann Perry, ARS Public Affairs Specialist; and Rachel F. Steele, National Climate Hubs Coordinator.

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September 2015

**Contributors:** Our thanks to Edwin Almodovar, NRCS; Juliet Bochicchio, RD; Kimme Bryce, RD; Rudy O'Reilly, RD; Michelle Thurland-Martinez, RD; Wendy Hall, APHIS; Marlene Cole, APHIS; José Urdaz, APHIS; Sharon Hestvik, RMA; Juan M. Ortiz Serbiá, FSA; Rick Dantzler, FSA; Ricardo Goenaga, ARS; Carlos Hasbun, FAS; and Virgilio Mayol, FAS.

**Edited by:** Ann Perry, ARS

	Coffee	Grasses	Specialty	Livestock	Forestry
Flood and sea level rise	Timing and amount of precipitation important to phenology of coffee. Negative effects of increased erosion and nutrient loss.				
Drought					
Temperature shifts					
Pests and disease					
Socio-economic					
Extreme weather					
Additional climatic factors					



## Assessments

# *Document vulnerabilities and adaptation practices by sector*

- Developed scientific base to build communications
- Developed new relationships among researchers and institutions
- Documented most recent climate science
- Assessed established sectors and emerging crops and markets
- Included section on socio-economic factors contributing to vulnerability
- Special emphasis on water issues







## Assessments

# Assessing the stakeholder landscape

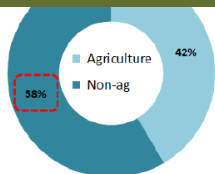
*Within USDA, agricultural advisors, farmers and land managers*

Gathering information:

- Workshops
- Webinars
- Farm visits
- Questionnaires
- Published literature



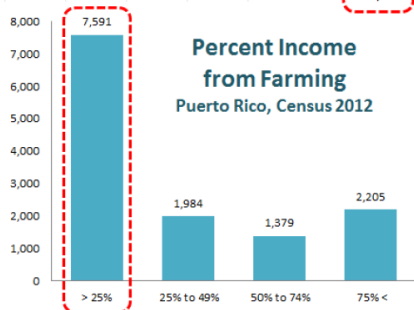
### Caribbean Context



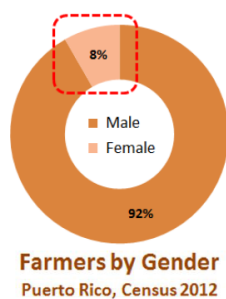
Farmers by Primary Occupation  
Puerto Rico, Census 2012



Farmers by Age Group  
Puerto Rico, Census 2012



Percent Income from Farming  
Puerto Rico, Census 2012



Farmers by Gender  
Puerto Rico, Census 2012



Understanding the flow of information:  
Stakeholders are diverse, information delivery should match the diversity of stakeholders





## Strategy

*Build on the science in the vulnerability assessment*  
*Have a portfolio of information delivery mechanisms*

- Work with influential farmers
- Get information in the hands of Extension S
- Have an integrated message regarding adaptation
  - Research papers
  - Reports
  - Podcasts
  - Webinars
  - Videos
  - Factsheets
  - Model farms



Caribbean Regional Climate Sub Hub  
 Assessment of Climate Change  
 Vulnerability and Adaptation and  
 Mitigation Strategies



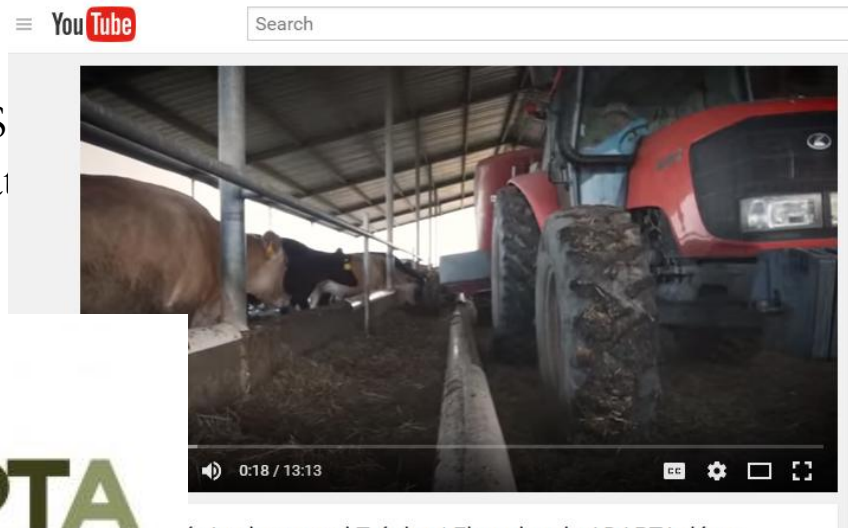
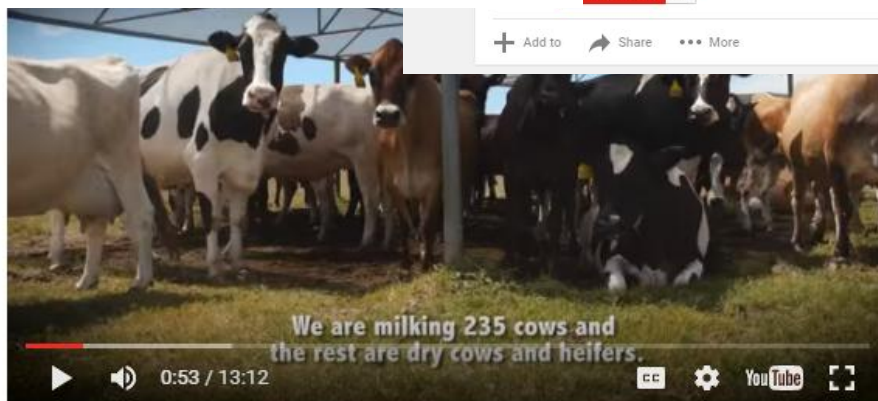
Authors: William A. Gould, U.S. Forest Service (USFS) International Institute of Tropical Forestry (IITF) Research Ecologist; Caribbean Sub Hub Director; Ingemar J. Pina, Caribbean Sub Hub Strategic Analyst; Tula University graduate student; Sukh K. Paine, Caribbean Sub Hub Coordinator; Estelina McGowan, IITF IITF Forest Scientist; Ann Perry, ARS Public Affairs Specialist; and Rachel F. Smith, National Climate Hub Coordinator.

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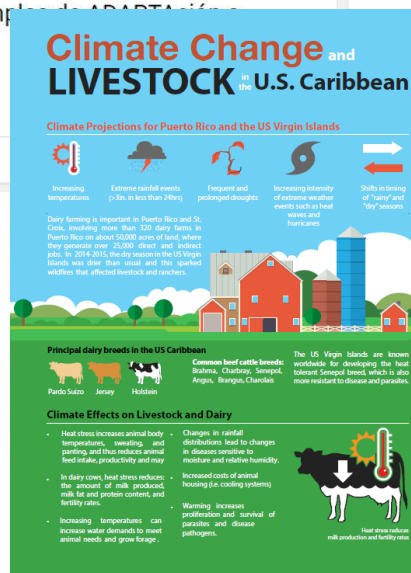
September 2018

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Edited by: Ann Perry, ARS



La Lechera en el Trópico | Ejemplos de ADAPTACIÓN  
 Climáticos en la Agricultura  
 Caribbean Climate Hub  
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## Strategy

*Build on the science in the vulnerability assessment*  
*Have a portfolio of information delivery mechanisms*

Videos and podcasts

## Factsheets

# CAMBIO CLIMÁTICO

Fundamentos básicos

¿Qué es el clima? Según la Organización Meteorológica Mundial, el clima es el estado más frecuente de la atmósfera de un lugar. El clima es una descripción estadística de los promedios en temperatura, lluvia, y vientos por un largo periodo de tiempo, usualmente 30 años.



## EDUCATIONAL VIDEOS & PODCASTS

### Serie Educativa AD

Ejemplos de Adaptación Agrícola al Cambio Climático  
 ADAPTA es un proyecto de divulgación científica sostenible que agricultores, ganaderos y pueden adoptar para incrementar su resiliencia climática. ADAPTA documenta historias de agropecuarios en Puerto Rico que practican recursos como el suelo y el agua, la rotación integrada de plagas, el compostaje de residuos agroecológicos y demás buenas prácticas.



## USDA Climate Hub Concept in the Americas Workshop

August 18-19, 2015

### FINAL REPORT

Josh Fain, William Gould, Isabel Parés, Kathleen McGinley and Jill Luxenberg



Workshop reports



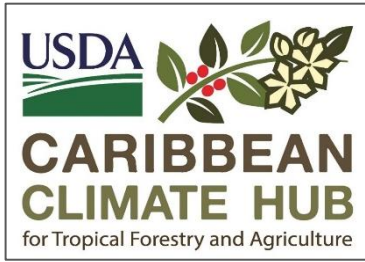


## Goal

*Farmers are implementing best practices for adaptation and mitigation while increasing productivity and sustainability*







## Further steps

### *Monitor and assess effectiveness*

- Quantify the effects of communications, tools, and adaptation practices.
- Feed information back to develop new science, tools, and relationships.
- Align incentives to best practices and to societies goals.
- Better integrate agriculture and forestry in land use planning.

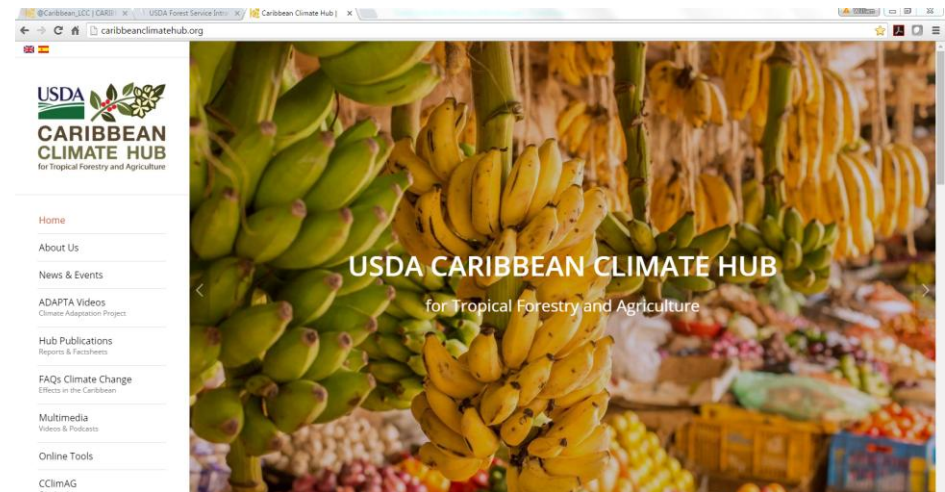




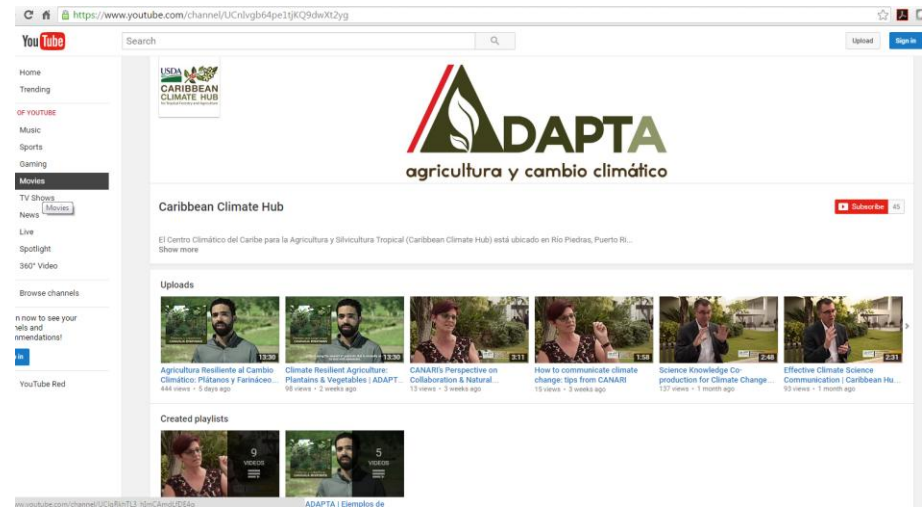
## Tools and contacts



<http://desdelaeea.eea.uprm.edu/>



[caribbeanclimatehub.org](http://caribbeanclimatehub.org)



[youtube.com/Caribbean climate hub](https://youtube.com/Caribbean climate hub)

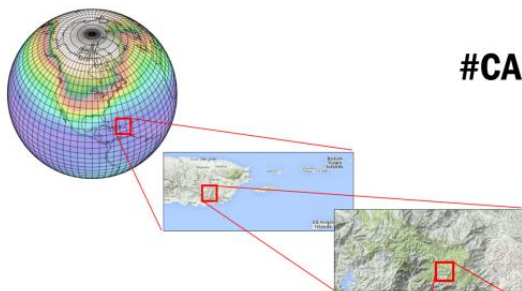


# Caribbean Climate Webinar: Status of Developing Multi-Model Ensemble Projections for Ecologically Relevant Climate Variables in Puerto Rico & U.S. Virgin Islands

## Upcoming webinar

Monday, June 27th, 2016 at 2:00PM

**#CARIBBEANCLIMATETALKS  
WEBINAR**



### SAVE THE DATE

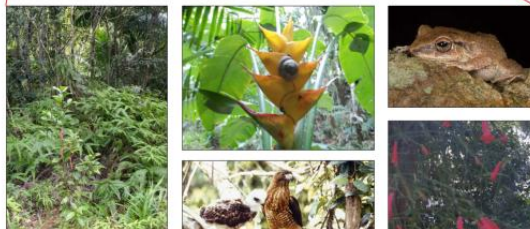
#### Caribbean Climate Webinar:

Status of Developing  
Multi-Model Ensemble  
Projections for Ecologically  
Relevant Climate Variables in  
Puerto Rico & U.S. Virgin  
Islands

**Monday, June 27, 2016**

**2:00PM EST**

**Speaker: Dr. Jared Heath Bowden**  
Research Assistant Professor,  
UNC-Chapel Hill







Gracias

[wgould@fs.fed.us](mailto:wgould@fs.fed.us)

